MODIS DATA STUDY TEAM PRESENTATION

January 4, 1991

AGENDA

1. Action Items
2. Assumptions List for the MODIS Level-1A Processing System
3. MODIS Level-1A Data Flow Diagrams
4. MODIS Level-1A Data Dictionary

ACTION ITEMS:

10/19/90 [Al McKay and Lloyd Carpenter]: Expand introductory material in Earth Model write-up to include broad discussion of MODIS geolocation and need for Earth model. Coordinate with Al Fleig to distribute report. STATUS: Open.

11/16/90 [Doug Hoyt]: Review MODIS Level-1 data flow diagrams and identify data items potentially provided by the MCST. Provide a list of instrument parameters required to Earth locate MODIS pixels (e.g. detector locations, electronic delays, mirror rotations, etc). STATUS: Presently available information insufficient to address item. Report due approximately one year from the assignment date. Open.

12/7/90 [Daesoo Han]: Arrange a meeting with appropriate EOSDIS civil service personnel to discuss data processing services to be provided on each side of the EOSDIS/MODIS interface and to set up communications structures to periodically review the needs and expectations of system developers working both sides of the interface. STATUS: Open.

12/14/90 [Lloyd Carpenter and Al McKay]: Add detail to the previous discussion of numerical offsets between ellipsoid and geoid referenced pixels, analyze the differences in computational requirements using the two Earth models, and integrate new and previous write-ups on Earth models into a single discussion. STATUS: Report in this week's handout. Closed.

12/21/90 [Watson Gregg and Al McKay]: Combine Earth Model reports into single document. Pursue 2 additional questions: 1) how important is the geoid/spheroid difference over the oceans, and 2) how important is the difference over land, considering the types of DEM/DTM's likely to be used? STATUS: Open.

12/20/90 [Watson Gregg]: Make revisions of anchor point accuracies report. STATUS: Revised and delivered.

ASSUMPTIONS LIST FOR MODIS LEVEL-1A PROCESSING SYSTEM

1. Data will be broken out and stored as granules with a granule header. These granules are larger than the scan cube but no larger than an orbit.

Justification: Many data processing activities are facilitated by the creation of data granules of reasonable size -- memory and storage can allocated, and processing software is easier to write and handle. Metadata, a required output product, will be in granule format in order to describe a coherent part of the data. So granules must be created at Level-1A anyway. Reasonably-sized granules also facilitate the recovery of data quality information, particularly the data completeness and existence parameters. Such granules have been used for many satellite sensors, with apparent success. Finally, and perhaps more importantly, reasonably-sized granules are convenient, both in the data system design but also to users, who are adjusted to operating with coherent sets of data.

2. Instrument Status Information contains the instrument operating status.

Justification: Needed for data quality information and for Assumption #3.

3. MODIS processing should compare the instrument operating status as contained in Level-0 data with that contained in the Instrument Status Information.

Justification: Operating status is important to the user in order to interpret and use the data. Instrument operations personnel should also be aware of discrepancies.

4. MODIS Quick- Look processing may require time ordering, redundancy elimination, and quality control measures not required for standard MODIS processing.

Justification: CDOS may not be able to provide routine processing services that meet Quick Look data timeliness constraints.

5. All data packets with an Application Process ID[1] that designates MODIS data will be retained in the MODIS Level-1A product.

Justification: Data addressed to MODIS will not be retained by any other instrument service.

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[1] Packet address field as defined in "Packet Telemetry", CCSDS 102.0-B-2, CCSDS Secretariat, Code TS, NASA, Washington, D.C.

6. MODIS packets will be provided with a secondary header that includes a scan sequence counter (which increments once for each instrument scan), and a packet sequence counter that indicates the position of a data packet within the scan cube.

Justification: This information is required to insert packet data into the proper location in the granule structure.

7. Level-1A processing is reversible, but not necessarily to re-create Level-0 data as it was originally stored in the DADS. Instead, re-created Level-0 data may be time-ordered packets of original data.

Justification: The time-ordering process in the Level-1A processing scheme will not keep track of the order in which Level-0 data were originally stored, thus exact reversibility is impossible. Furthermore, duplicates will be removed, thus also making exact reversibility impossible. However, the spirit of the reversibility requirement is to be able to recover the full set of instrument data. Our processing scheme meets this test. However, if Level-0 data is processed by CDOS as stated in the ECS Requirements Document, i.e., time-ordered data with duplicates removed, then our processing involves no additional time-ordering or duplicate removal, and exact reversibility is achievable.

A Description of the Proposed MODIS Level-1A Granule Internal Data Structure.

The logical visualization of the granule structure contains an integer number of scan cubes. Each scan cube is composed of a cube header, a matrix of science (detector) data in a three dimensional representation, and ancillary data referenced as engineering data. The three dimensional science data corresponds to the across track line scan, along track multiple scan lines and depth corresponding to wavelength (bands). The present numbers for MODIS-T are 1040 pixels in the across track scan dimension, 30 scan lines along track, and 32 bands at differing center wavelengths . The data granule has a granule header appended at the begining of the granule structure. The size of a cube of data is expected to approach 2 megabytes with the size of a granule, composed of many cubes, being too large to fit into a reasonable amount of computer memory. To process the incoming granule of data, an implementation of a demand paging is proposed.

The computer memory for the data granule is sized to hold two cubes of data at the same time. The remaining cubes of data will be swapped between a disk backing store and the computer memory. It is assumed that the size of a data set granule will be known in advance of the processing and that sufficient disk storage can be pre-allocated before processing of incoming data begins. The packets of incoming data are expected to be approximately 1000 bytes in length thereby requiring approximately 2000 packets of data to fill a scan cube of information. The packets of data are generated at the instrument in a time ordered sequence but may be received at the EOSDIS facility in a slightly non-time ordered sequence due to the nature of the store and forwarding intermediate data transmission steps. In other words, the locality in time of the arrival of packets will be time ordered but will include a random small delta time offset. The probability that packets will be placed within one scan cube location in any time interval is large and the probability that sequential packets will be scattered across more than two scan cubes is extremely small. Therefore, keeping two scan cubes in memory at a time will allow an extremely high probability that the cube in which the packet belongs will be in memory.

The backing store is managed by the MODIS Level-1A program and consists of a disk file with random direct access. This disk file will contain the output data product at the completion of the processing and the ownership of this file can be passed to subsequent processors by name thereby eliminating an actual transfer of data. The metadata file will not have a backing store and must be passed directly.

GRANULE STRUCTURE

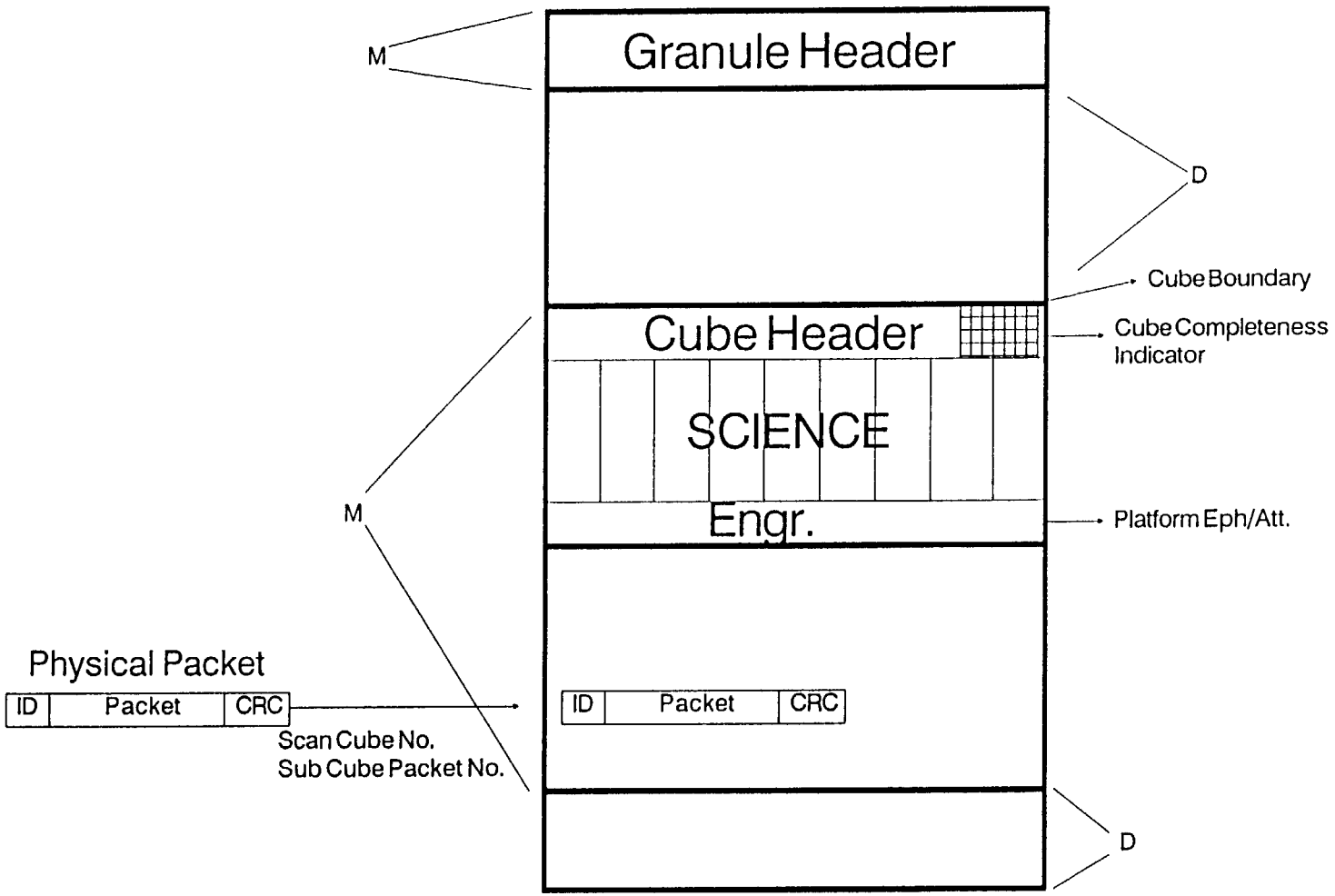

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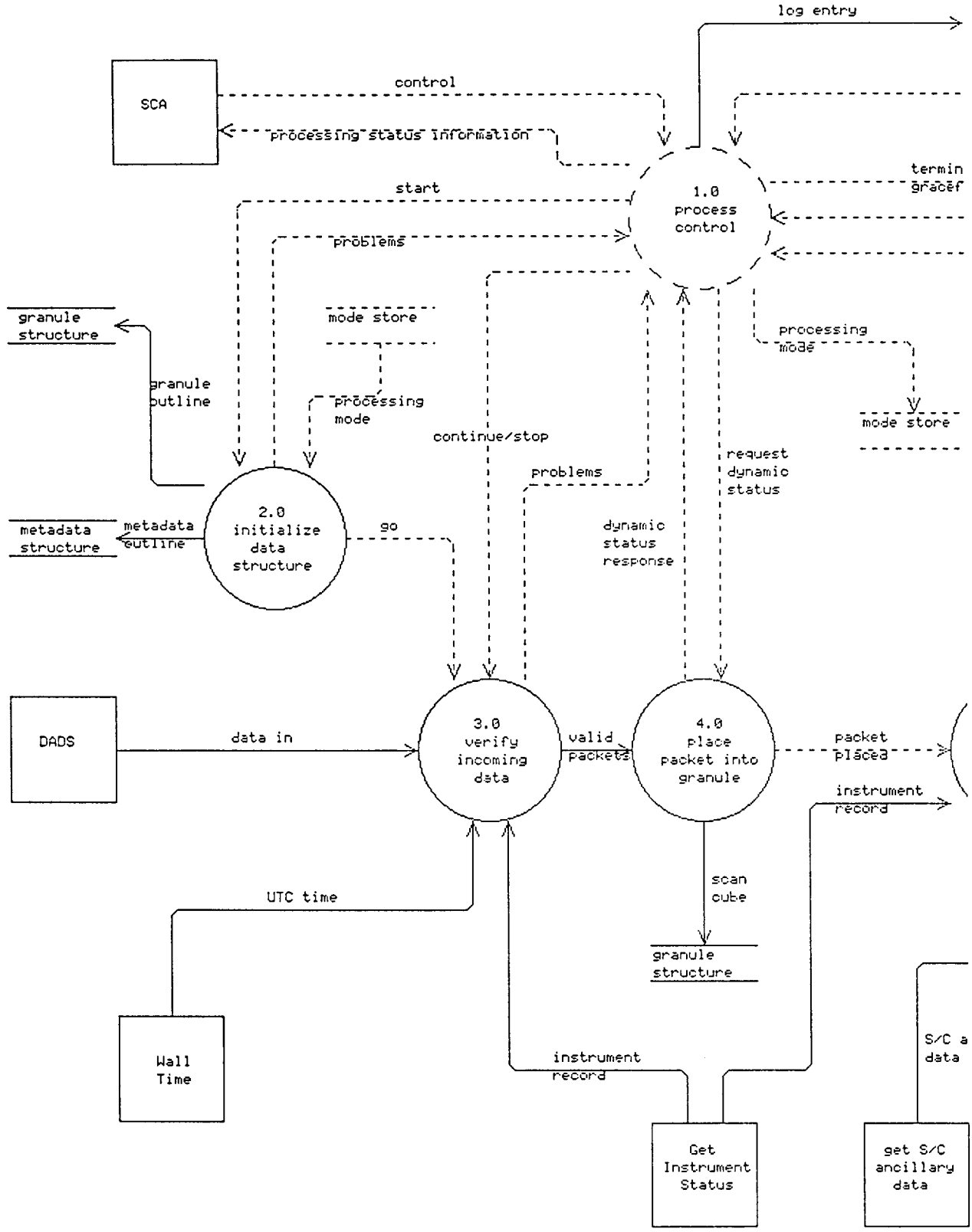
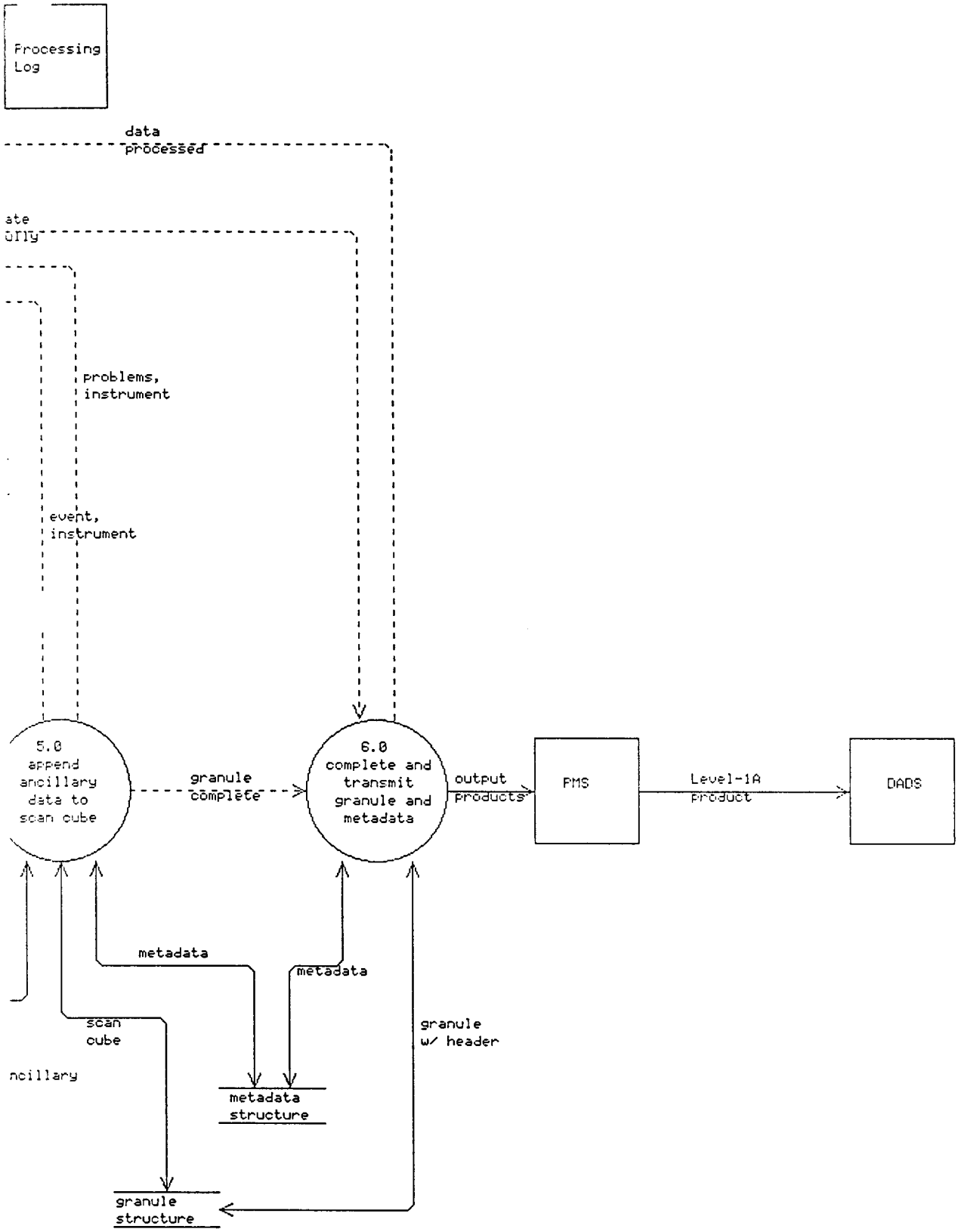
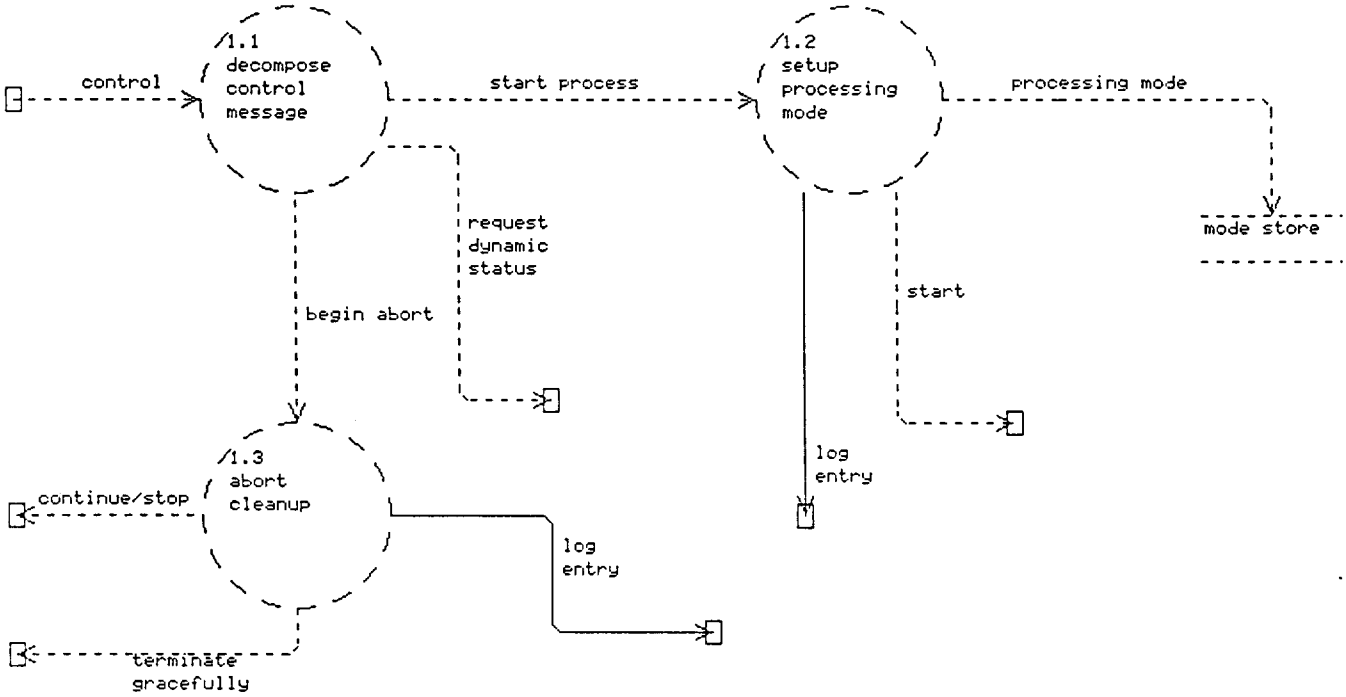
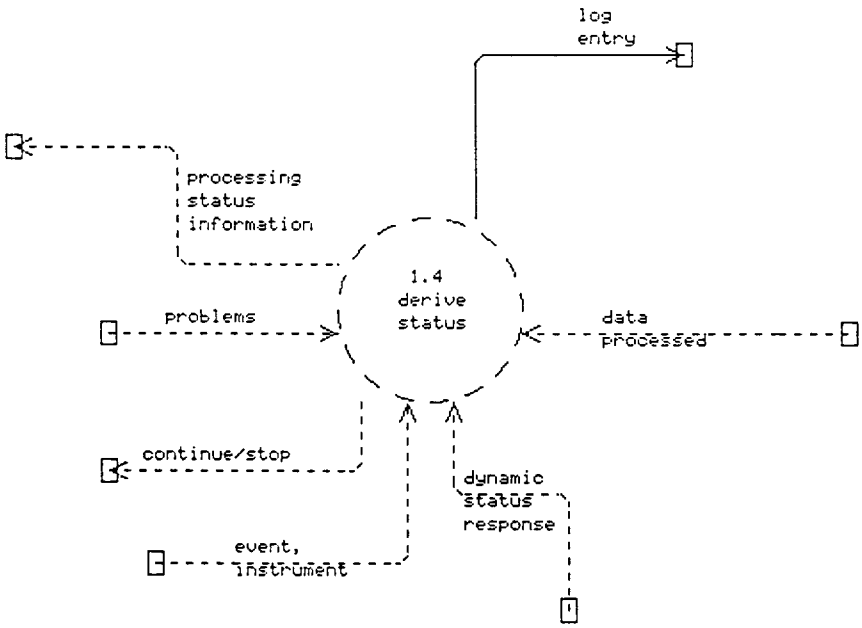
Chart : a
Filename : a.trg
Last Modified : 01-03-1991




Processing Log
data processed
ate
only
problems, instrument
event, instrument
5.0 append ancillary data to scan cube
granule complete
6.0 complete and transmit granule and metadata
output products
PMS
Level-1A product
DADS
metadata
metadata
scan cube
granule w/ header
ncillary
metadata structure
granule structure

Project : \ECPLUS\MODIS-1A\
Chart : b-1
Filename : b-1.trg
Modified : 01-03-1991





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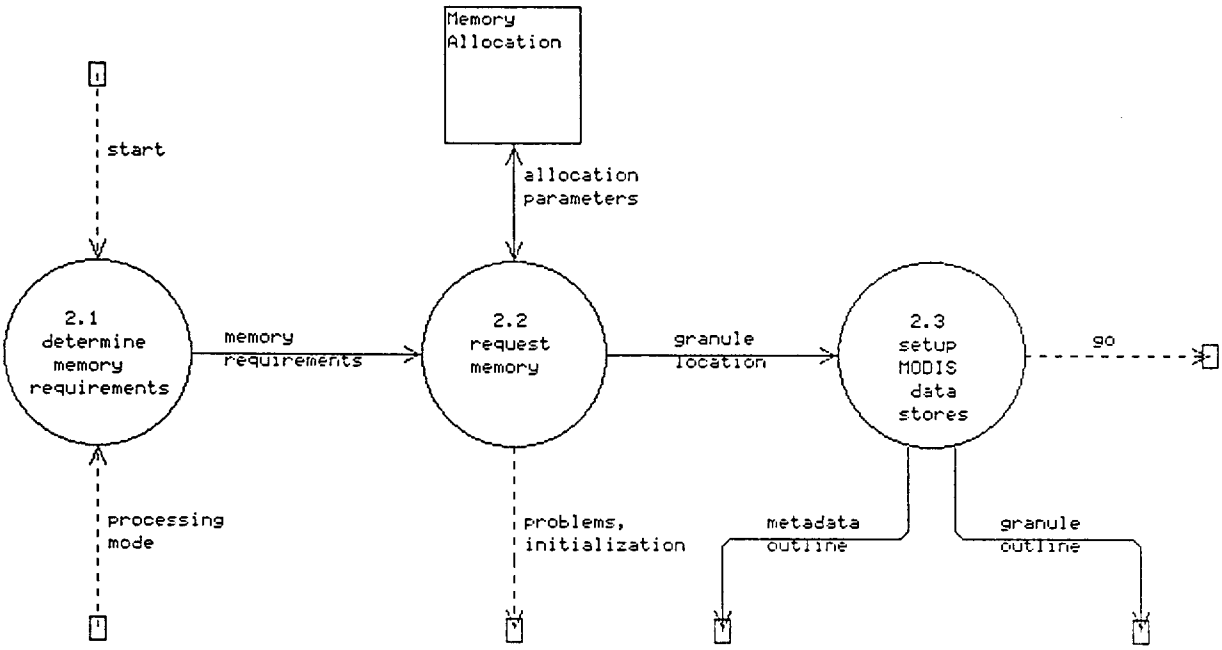

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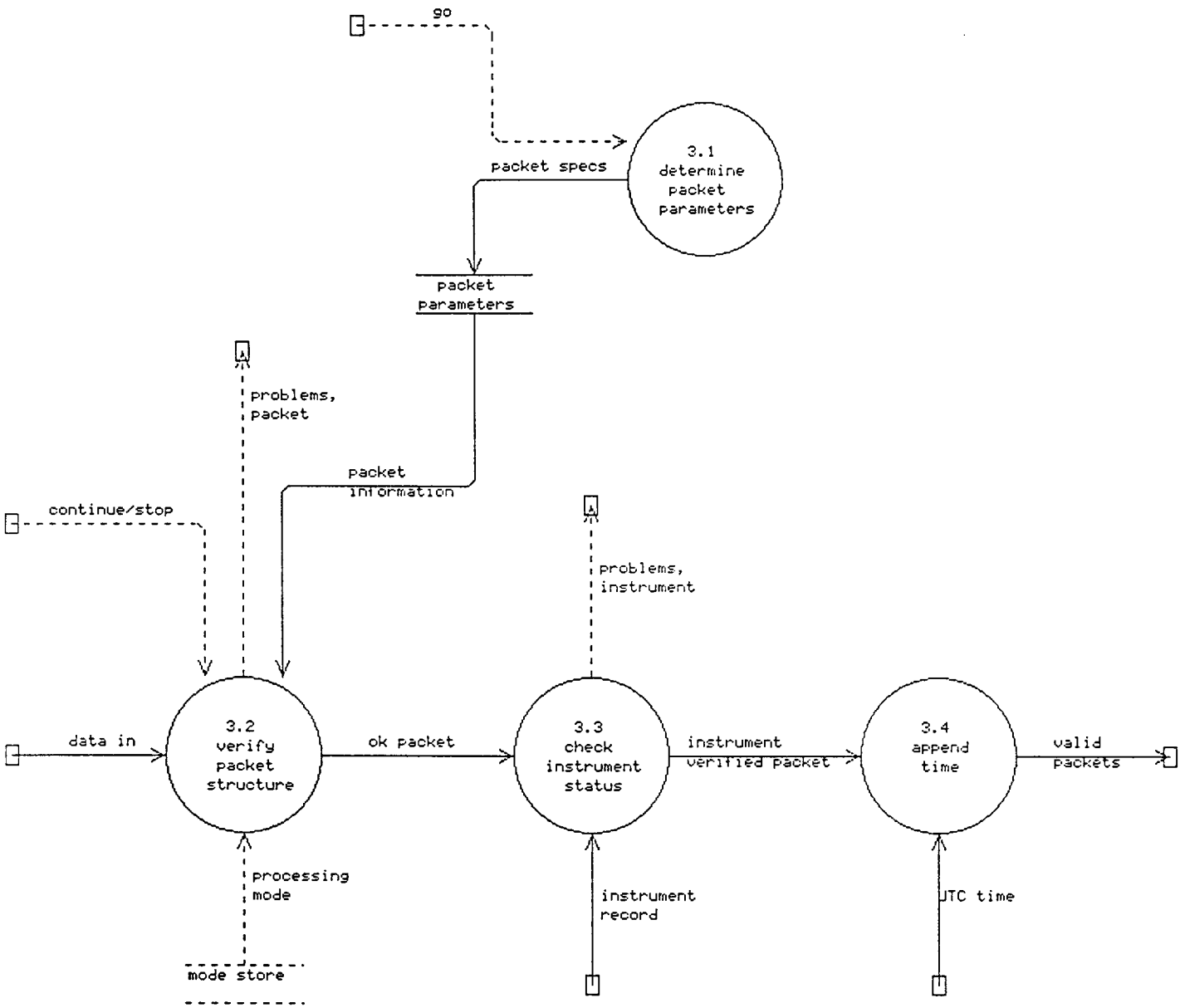

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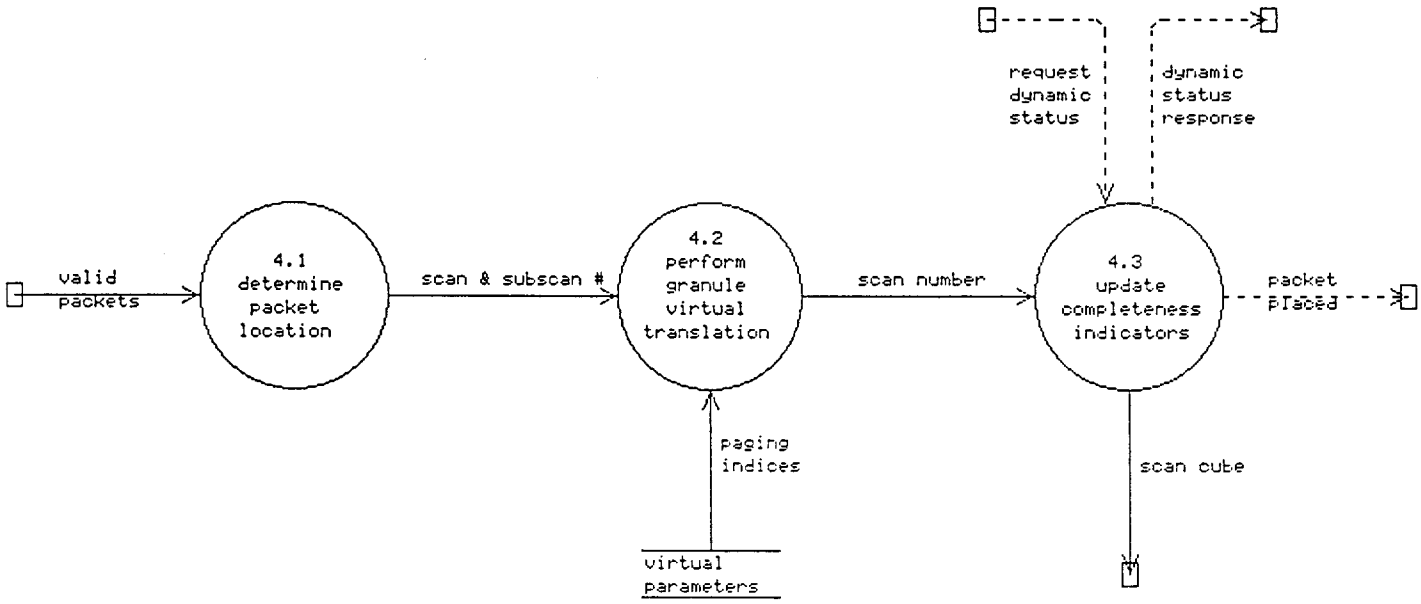
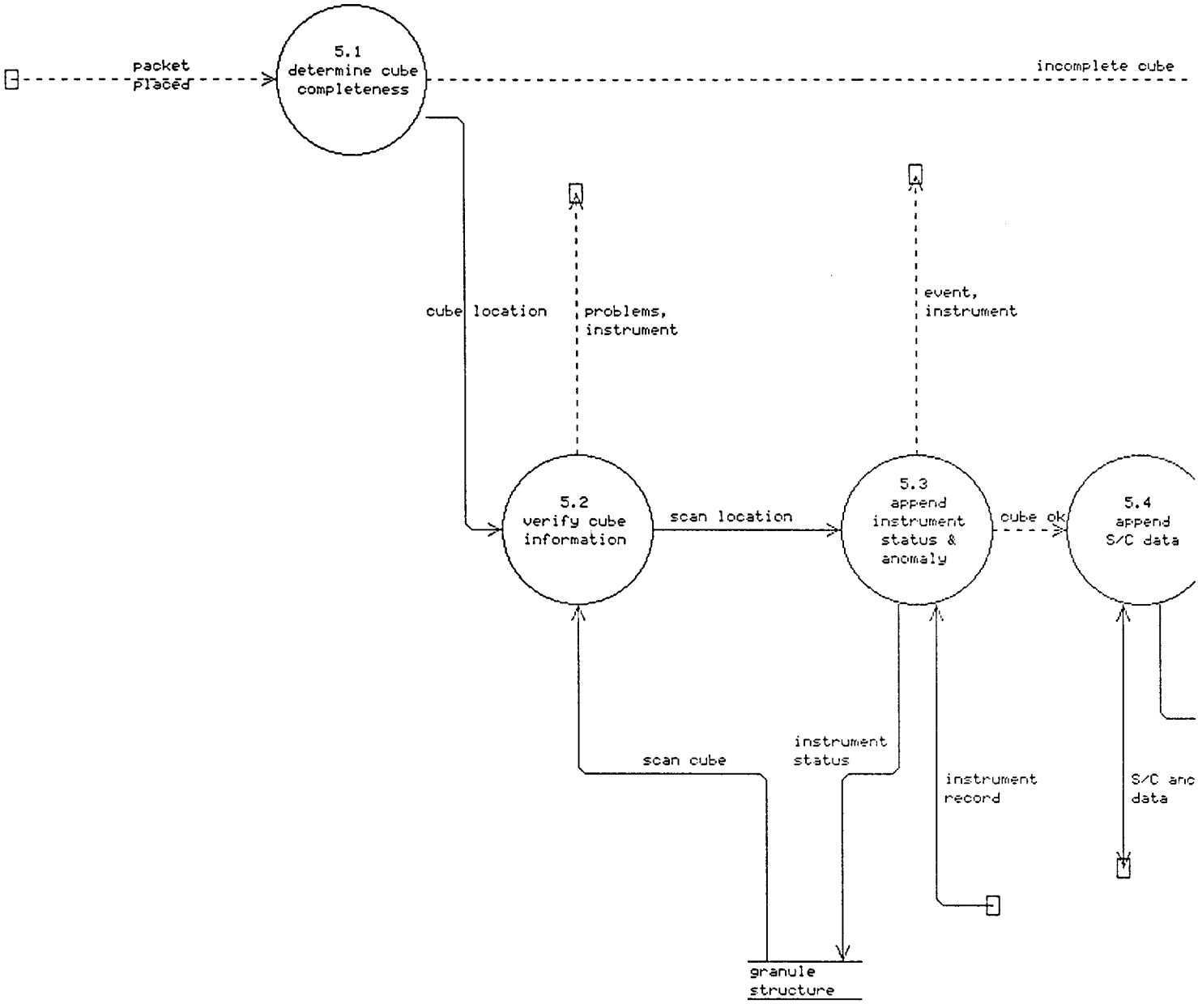
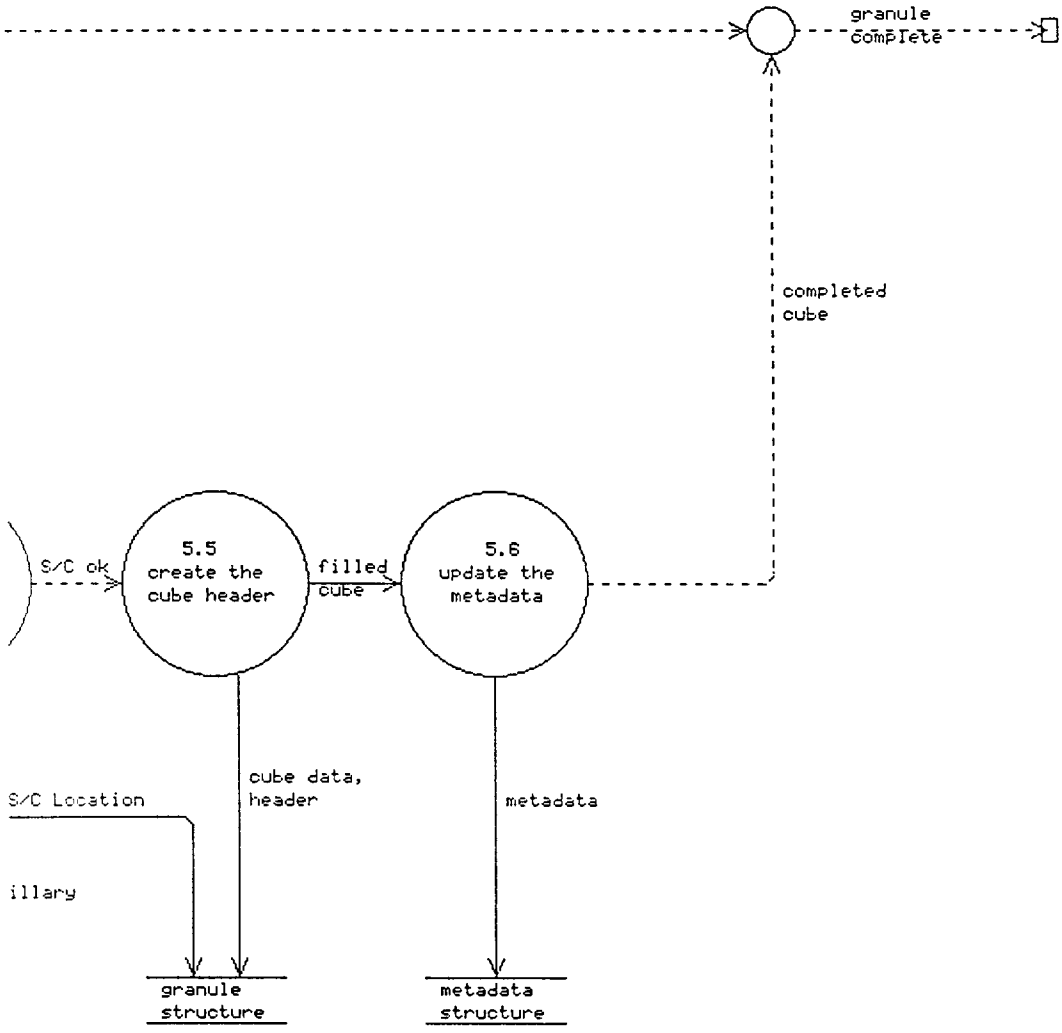
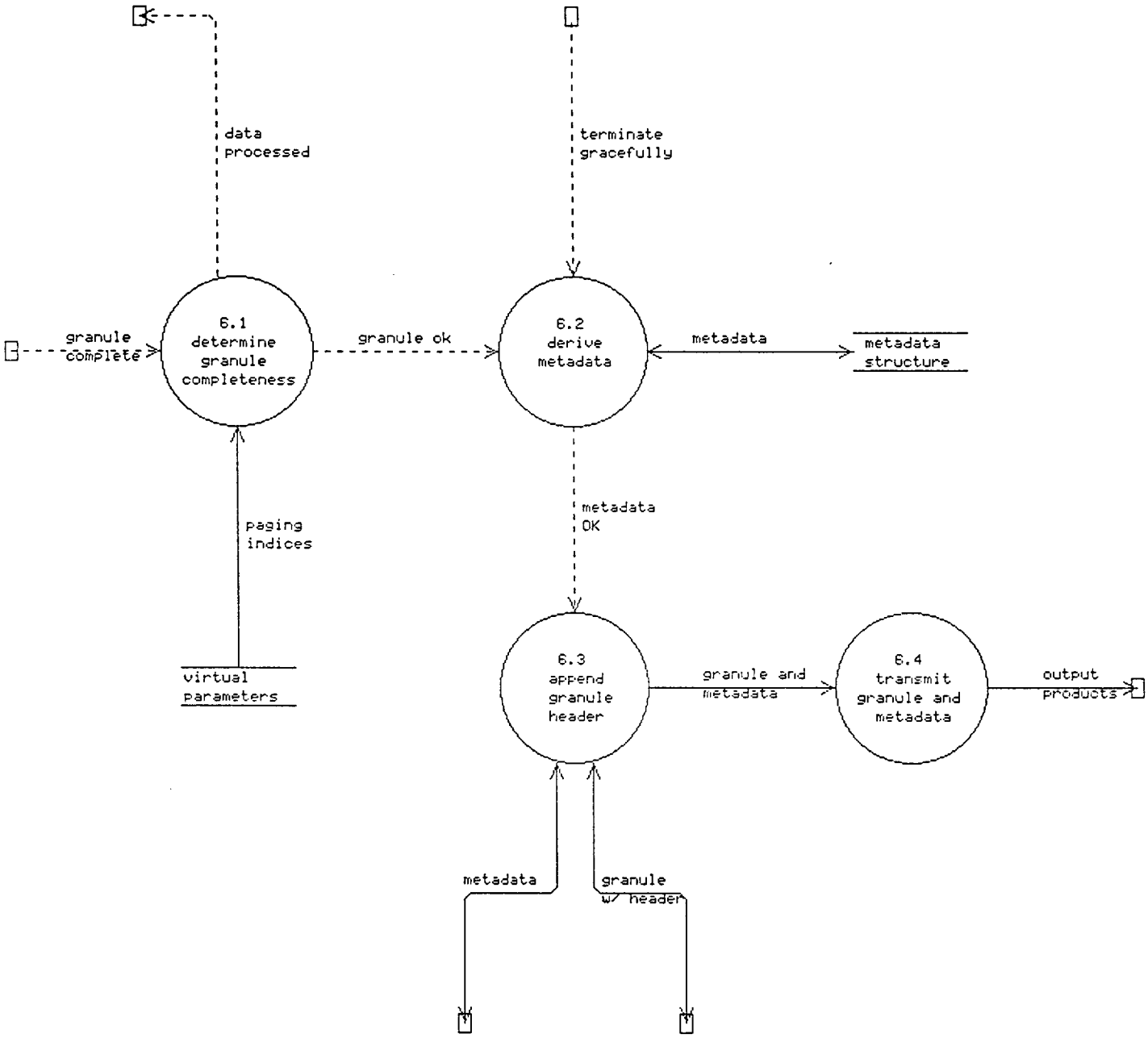


Project : \ECPLUS\MODIS-1A\
Chart : b-5
Filename : b-5.trg
Modified : 01-03-1991




granule
complete
completed
cube
S/C ok
5.5
create the
cube header
filled
cube
5.6
update the
metadata
cube data,
header
metadata
S/C Location
illary
granule
structure
metadata
structure

Project : \ECPLUS\MODIS-1A\
Chart : b-6
Filename : b-6.trg
Modified : 01-03-1991



Project : \ECPLUS\MODIS-1A\

D: ictionary Entry Description Attribute Report for Object Type = All
(* ndicates deleted DDE)

Object Identifier	Object Type	Description Attribute
Begin Abort	Control Flow	An indicator to begin an orderly abort of the processing. Files are not posted. Either a graceful termination or an immediate abort.
Completed Cube	Control Flow	All data necessary to complete a scan cube of information has been performed, and the granule has been updated. A message with the scan cube location description.
Continue/Stop	Control Flow	An indication to continue or stop processing data. Ask for the next packet, or stop asking for packets from the DADS.
Control	Control Flow	A message that informs the process which mode to operate in, to start, cancel, suspend, resume, to request and return status (dynamically or statically), and to request and verify the staging and/or destaging of data to/from the DADS.
Cube OK	Control Flow	An indication that the scan cube of data has completed instrument related anomaly processing.
Data Processed	Control Flow	An indication that the process is ready for the next packet. It will also contain an indicator of granule completeness and any error conditions.
Dynamic Status Request	Control Flow	A control item requesting that processing information be posted into a return message. See Dynamic Status Response.
Dynamic Status Response	Control Flow	An internal message that indicates the current status (accounting) of the data processing task.
Event, Instrument	Control Flow	An anomaly has been detected in any of: instrument status between instrument record log and telemetered data, or similiar non catastrophic problem. Does not require immediate attention.
Go	Control Flow	An indication that tells the processor that the store areas have been defined and that data processing can begin.
Granule Complete	Control Flow	All tests for a completed scan cube have been performed, no judgement is made of the results of these tests.
Granule OK	Control Flow	An indication that a full granule of data is available and that metadata determination can begin.
Incomplete Cube	Control Flow	An indication that a scan cube has not been completed. More packet data are required.
Metadata OK	Control Flow	An indication that final granule metadata processing is complete.

Packet Placed	Control Flow	A packet (subcube) of data has been placed into the proper granule location in memory, paging if necessary.
Problems	Control Flow	This message can signal an end of data input, signal bad or inappropriate data, request an alarm generation, or other potentially catastrophic (probably stop processing) problem.
Problems, Initialization	Control Flow	A message indicating that a potentially catastropic problem has been detected, such as not enough store space to process the data. This is an alarm, not an event.
Problems, Instrument	Control Flow	An instrument serious discrepancy has occurred (i.e. turned off). This is an alarm, not an event.
Problems, Packet	Control Flow	An alarm message: the process has encountered the last packet, or has encountered a bad/illegal packet.
Process Control	Control Flow	A message from the SCA consisting of: initiate process w/ mode - quick-look, standard, reprocessing dynamic status request; suspend operations; terminate process - now or gracefully.
Processing Mode	Control Flow	A message containing the mode of processing to be performed. (e.g. standard processing, reprocessing, quick-look.)
Processing Status	Control Flow	A message to the SCA containing: dynamic status response; post processing record; alarm/event with anomalies, faults, and exceptions.
Processing Status Information	Control Flow	Information regarding the fault conditions and processing performance of this processor. Status or completion information from the MODIS process to the SCA. May be abnormal, dynamic, or normal termination messages.
S/C OK	Control Flow	An indication that the space craft ephemeris and attitude data have been appended to the proper scan cube structure.
Start	Control Flow	Starts the process with initialization parameters from which the store sizes can be calculated.
Start Process	Control Flow	The result of an "initiate processing" message type being passed to the MODIS processor from the SCA.
Terminate Gracefully	Control Flow	An indicator that instructs the process to finalize any remaining products, clean up and return data stores to the operating system, and post/close any files used.
Mode Store	Control Store	A store containing all information necessary to determine the scope of processing to be performed. I.e. begin and end time, # of packets, mode, etc
Abort Cleanup	Control Transform	Processes the termination messages into the proper flow control items. This can be a graceful or abort-now condition. Posts an entry to the Processing Log.

Decompose Control Message	Control Transform	Parses the incoming message to determine message type and where to send it.
Derive Status	Control Transform	Handle problem and event messages as well as termination messages, post the system processing log message and pass a message to the EOSDIS SCA processor.
Process Control	Control Transform	Handles the control functions of the processor. Interfaces with the context environment via the EOSDIS SCA process.
Setup Processing Mode	Control Transform	Derives the mode parameters, posts an entry to the system processing log, and starts the show.
Allocation Parameters	Data Flow	A request to the operating system for storage allocation, and a response with the parameters, or an error indication.
Cube Data, Header	Data Flow	The scan cube (not structure) header information for this completed cube of MODIS data (including selected metadata items) to be placed into the granule structure.
Cube Location	Data Flow	The memory location of the completed scan cube. This cube must be in memory, not in the disk backing store.
Data In	Data Flow	Level-0 data or quick-look data in packet (subcube) form.
Filled Cube	Data Flow	A scan cube of data has been filled with all data from the satellite, including the cube header. Metadata and scan cube completeness indicators to follow.
G le Outline	Data Flow	Addresses, sizes, and types of the MODIS granule store area. This includes disk and memory areas. The store area values are initially defined with invalid data.
Granule and Metadata	Data Flow	A flag indicating that all granule processing has been performed and this granule can be transmitted (actual or pointer) to the PMS.
Granule w/Header	Data Flow	All granule header information including most or all metadata items.
Input	Data Flow	Includes all of: Level 0 data w/science, engineering, & audit trail; Spacecraft ancillary w/ audit; Quick-look data; Locally maintained databases w/ browse criteria; Metadata w/ anomaly & audit trail.
Instrument Record	Data Flow	The current state of the MODIS instrument at the specified time. This is an integration of all previous status commands, not a history of status events.
Instrument Status	Data Flow	MODIS instrument information derived in combination with the telemetered and the Instrument Log information. This may include status as well as characterization parameters.
I ument Verified Packet	Data Flow	A flag indicating that an OK packet with time tag added and instrument status has been processed.
Level-1A Product	Data Flow	MODIS level-1A product, verified by PMS (IMS) which are then passed to the DADS for dissemination.

Log Entry	Data Flow	A record to be posted in the EOSDIS (or other) master processing log. This leaves an audit trail in the legal sense.
I y Requirements	Data Flow	The derived size of the level-1A storage area needed to process this granule of data.
Metadata	Data Flow	Information derived from data sets that provides an understanding of the content or utility of that data set.
Metadata Outline	Data Flow	Addresses, sizes, and types of the metadata store allocation. This sets up the metadata memory area and initializes that area with predefined values representing invalid data.
OK Packet	Data Flow	A flag indicating that a correct packet has been obtained.
Output	Data Flow	Consists of: Level-1A data product w/ header, data,DQ information; Processing Log; Metadata w/ audit trail; Browse data; Quick-look product.
Output Products	Data Flow	MODIS level-1A data product consisting of metadata, and the level-1A data granule. This can be standard, quick-look, or reprocessed products.
Packet Information	Data Flow	size, ID location, etc. of packet structure parameters. To be used to verify that the correct packets have been received from the DADS.
P t Specifications	Data Flow	Packet parameters to be used for verification of the packet integrity (not instrument data).
Paging Indices	Data Flow	Internal pointers and flags that are used to manage the virtual to/from physical addressing of the MODIS granule structure.
S/C Ancillary Data	Data Flow	Spacecraft ephemeris and attitude data obtained from a database within the EOSDIS system.
S/C Platform Location	Data Flow	
Scan Cube	Data Flow	Data (science and engineering) in a scan cube format with ancillary data appended. Scanning parameters are TBD.
Scan Location	Data Flow	An indication that the instrument data within a scan cube has been processed and that additional scan items need further processing.
Scan Number	Data Flow	The number of the scan cube and location that the current packet belongs in.
Scan and Subscan Number	Data Flow	The scan cube number and packet subscan number which determines the location of this packet in the level-1A structure.
UTC Time	Data Flow	EOSDIS universal time. Similar to GMT. Used to time stamp processor log entries and data packets (for inclusion in the data cube).
Valid Packets	Data Flow	Packets of subcube data that have passed packet, not data, sanity checks such as instrument ID, packet size, etc.
Append Granule Header	Data Process	Append this granule (not scan cube) header to the granule product. This

		will include most or all of the values from the metadata as well as other information.
Append Instrument St. & Anomaly	Data Process	Determine any instrument based information (characterization) and post any status or derived items into the granule.
Append S/C Data	Data Process	Append platform ephemeris and attitude information to the scan cube. This represents the S/C data in the neighborhood of the scan cube time, not at the scan cube time.
Append Time	Data Process	Append current EOSDIS UTC time to the packet. This allows for an audit trail and an indication of packet time locality for future processing refinement.
Append to Scan Cube	Data Process	Test for a completely filled scan cube of data, append instrument and S/C data to the scan cube, create the scan cube header, and update selected metadata values.
Check Instrument Status	Data Process	Examine the instrument bits for ON/OFF, state, other instrument sanity checks.
Complete and Transmit G & M	Data Process	Perform final accounting at the granule level, fill in remaining metadata items, determine and apply the granule header, and deallocate memory and disc stores.
Create the Cube Header	Data Process	Determine all the items to be placed in the header of a scan cube. This includes the completness indicators.
Derive Metadata	Data Process	Determine all the remaining metadata values to be placed into the metadata store. If CDOS supplies a management information record (MIR) or a post event record (PER), then it will be appended to the MODIS metadata product.
Determine Cube Completeness	Data Process	Check completeness flags to see if this scan cube has all its data. A preliminary accounting of the number of subscans placed in this cube will speed up this process.
Determine Granule Completeness	Data Process	Determine if the entire data set granule has been filled. If so, indicate a desire to terminate, but allow further packets to be processed. This allows duplicate packets to be handled and accounted.
Determine Memory Requirements	Data Process	Calculate the memory and backing store size requirements as a function of the requested input data set size, mode, or other parameters.
Determine Packet Location	Data Process	Extract the scan cube number and subscan packet number from the packet.
Determine Packet Parameters	Data Process	Set up and fill the store area with the parameters necessary to verify the packet integrity. These are derived from SCA information.
Initialize Data Structure	Data Process	Setup the memory areas (both memory and disc) for the output products (data set granule and metadata).

MODIS-1A Product Generation	Data Process	The process that generates level-1A data from level-0 data packets. This includes headers, status, data quality, and metadata.
[illegible]rm Granule Virtual Xlation	Data Process	Determine if the scan cube location for this packet is currently in memory. If not, perform the physical/virtual memory mapping with scan cube posting if required.
Place Packet into Granule	Data Process	Checks instrument status indicators, appends S/C platform ephemeris and attitude, updates packet accounting, optionally byte aligns data.
Request Memory	Data Process	Ask the operating system for system resources to allow processing of this data set. This includes processor and disk memories.
Setup MODIS Data Stores	Data Process	Determine and initialize all level-1A stores - either in memory or on disk as needed.
Transmit Granule and Data	Data Process	Pass either the data products (meta and granule) or pointers to the products to the external EOSDIS PMS processor for ultimate inclusion in the DADS after IMS validation input.
Update Completeness Indicators	Data Process	Set the bit for this packet location in the scan cube that indicates that these data have been found. If a dynamic status has been requested, generate a response accounting message.
U[illegible].e the Metadata	Data Process	Make any of the necessary metadata items current. An update process.
Verify Cube Information	Data Process	Perform a verification of data unique to the concept of a scan cube. This may be expanded to include noise analysis, A/D conversion verification, data orthogonality, etc.
Verify Incoming Data	Data Process	Perform sanity checks on the raw packets for packet integrity and instrument preliminary condition, and append a time stamp.
Verify Packet Structure	Data Process	Check for correct packet size, ID, CRC, and other sanity checks. Instrument data is not included here.
Granule Structure	Data Store	The storage area for the data set granule consisting of multiple scan cubes, multiple scan cube header, and a granule header. A scan cube consists of instrument science and engineering data.
Metadata Structure	Data Store	The storage area for the MODIS Level-1A metadata values.
Packet Parameters	Data Store	Specifiers of the packet size, ID, etc.
Virtual Parameters	Data Store	An internal store used to keep track of all counters and flags associated with the concept of a virtual demand paged storage allocation. This allows user defined page sizes which are each expected to be several MegaBytes in length.
DADS	External Entity	Data Archive and Distribution System. The database manager for input and

		output data.
Get Instrument Status	External Entity	The find current-instrument-status process. This is not a history of status events, but access to a flat file database of status versus time.
Get S/C Ancillary Data	External Entity	A separate process that returns platform ephemeris and attitude data in the neighborhood of the requested time.
Memory Allocation	External Entity	An operating system memory (and disk) allocation routine. A process requests storage allocation and the system returns error or location parameters.
PMS	External Entity	Product Management System - Performs data management of processed data, adds further DQ infomation before passing the data to the DADS.
Processing Log	External Entity	Log of processing status records, time sequential events. This is not the current status but a time based history of status events.
SCA	External Entity	Schedule, Control, Accounting. An EOSDIS process to perform scheduling of Product Generation System (PGS) programs.
Wall Time	External Entity	An EDSDIS or operating system service that returns the current time (=GMT).
a	trg	The first, upper (A) level of the MODIS level-1A structured diagrams. See also: the Context diagram. This is the beginning of the structured design Behavioral Model.
b	trg	The second (B) level diagram for the MODIS level-1A control functions.
b-2	trg	The second (B) level diagram for the MODIS level-1A initialization process.
b-3	trg	The second (B) level diagram for the MODIS level-1A incoming packet verification process.
b-4	trg	The second (B) level diagram for the MODIS level-1A packet placing process.
b-5	trg	The second (B) level diagram for the MODIS level-1A scan cube processor.
b-6	trg	The second (B) level diagram for the MODIS level-1A granule processor.
context	trg	The context diagram for the MODIS level-1A data processor. This is the structured design Environmental Model.
Flag	doc	An internal process variable or external operating system semaphore indicating an alert to another process.
Granule	doc	A convenient quantity of data with defin ed boundaries. This may be an orbit, scan cube, or other quantuum of data.
Indication	doc	A generic term for either a flag or a message. The type of indication (flag, semiphore, or message) is to be determined when the design is further advanced towards completion.
Message	doc	A buffer with information for another process (or subprocess). It may contain control information or data. The message is usually sent without waiting

		for an acknowledgement and initiates an external (to this process) action.
Packet	doc	A quantity of data that has no well defined boundaries other than size. The packet has data with appended header or data quality indicators such as frame syncs, CRCs, and/or Reed-Solomon error detection/correction.
Scan Cube	doc	A set of MODIS instrument data that corresponds to a sweep of the instrument mirror or other scanning device. A scan cube has three dimensions: along track, across track, and depth of wavelength or frequency.
Subcube	doc	A subset of a scan cube. The scan cube may be decomposed into packets, scan lines, bands, etc. The subcube is an element of the composite scan cube.

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117 Data Dictionary Entries Printed.